Silvicultural Report No. 18

Evaluation of the Eden SRK-880 Piling Rake and the Raumfix 4-Slash Piling Rake

Ontario

Ministry of Natural Resources

Hon. Alan W. Pope
Minister

John R. Sloan
Deputy Minister

ISBN 0-7743-8949-4
ISSN 0823-2156

G. Campbell, B.Sc.F.
Unit Forester
Blind River District

©1984 Government of Ontario

Printed in Ontario, Canada.

Additional copies of this publication
may be obtained from:
Ministry of Natural Resources
Public Service Centre
Room 1640
Whitney Block
Queen's Park
Toronto, Ontario
M7A 1W3

CONTENTS

Figures iii

Tables v

I Introduction 1

II Description of sites before treatment 2

III Silvicultural equipment 8

IV Organization of silvicultural operation 10

V Results of equipment trials 12

VI Observations and recommendations 18

VII Summary

Eden piling rake 20

Raumfix slash piling rake 21

FIGURES

1	The Eden SRK-880 piling rake mounted on a skidder	3
2	The Raumfix 4 slash piling rake mounted on a skidder	3
3	Location of slash clearing rake trials, Parkinson Township	4
4	Patterns of travel	11
5	Patterns of travel for clearing large slash	11
6	Eden rake modification	22
7	Slash accumulator for Eden rake	23
8	Springs hardware for Raumfix rake no. 4 mod.n	24
9	Bearing mount for Raumfix rake no. 4 mod.n	25
10	Replaceable teeth tips for Raumfix rake no. 4	26

TABLES

1 Site description -- mixed conifer slash on Eden rake treated areas 5

2 Site description — mixed conifer slash on Raumfix rake treated areas 6

3 Site description on tolerant hardwood treated areas 7

4 Silvicultural equipment test activity sampling 13

5 Costs per hectare 14

6 Post-site preparation assessment 17

I

INTRODUCTION

In the Blind River District bulldozers are commonly used for windrowing slash in preparation for planting or seeding. There are, however, several disadvantages in choosing this method of site preparation. These include high costs, poor quality of site preparation, and site limitations due to the suitability of the terrain and topography.

The costs of windrowing slash with crawler tractors have escalated in recent years owing to high purchase prices, repair costs, and fuel costs of the prime mover. In one 1981 equipment trial, costs of $193 per hectare were incurred when the familiar straight blade and hinged root rake was mounted on a bulldozer and used for site preparation. Productivity rates ranged from 0.32 to 0.36 hectares per productive-machine hours.

Although the quality of site preparation produced by a bulldozer is generally satisfactory, the windrows are likely to be poor. In addition, soil and stump-filled slash piles are difficult to burn and are therefore usually left to rot. Because the windrows cannot be subsequently planted or seeded, 15% to 25% of a given site is lost to forest production. Bulldozers are also limited to use on flat and gently rolling terrain with deep soils.

As a result of these limitations, in 1981 the District surveyed alternative prime movers and related equipment for both lower costs and applicability to a wider range of sites. The skidder-mounted Eden SRK-880 piling rake (see Fig. 1) and the Raumfix 4 slash piling rake (see Fig. 2) mounted on a 130 horsepower C6D treefarmer skidder were selected for testing in 1982.

This report examines the results of the tests for mixed conifer and tolerant hardwood slash types; analyses the performance of the rakes; and suggests possible equipment modifications.

II

DESCRIPTION OF SITES BEFORE TREATMENT

The eight cutover sites on which the rakes were tested are shown in Fig. 3. Each rake was tested on three mixed conifer sites and one tolerant hardwood site.

Mixed Conifer Test Sites

The original conifer stands, comprising poplar (Populus tremuloides Michx), white spruce (Picea glauca (Moench) Voss), and balsam fir (Abies balsamea (L.) Mill.), were approximately 78 feet in height and 78 years old when cut in 1980. Tree-length sawlogs and pulpwood were removed with skidders. The trees that were not removed were mainly poplar as well as some balsam fir. Descriptions of the sites before treatment are found in Table 1 for the Eden rake and Table 2 for the Raumfix rake.

Tolerant Hardwood Test Sites

The tolerant hardwood stands were estimated to be 79 feet in height and 154 years old when they were logged in 1981 and 1982. Hard maple (Acer saccharum Marsh.), yellow birch (Betula alleghaniensis Britt.), and hemlock (Tsuga canadensis (L.) Carr.) pulpwood and sawlogs were removed using skidders. Unmerchantable hard maple and over-mature yellow birch were left. Table 3 describes the tolerant hardwood sites before treatment.

Fig. 1: The Eden SRK-880 filing rake mounted on a skidder

Fig. 2: The Raumfix 4 slash piling rake mounted on a skidder

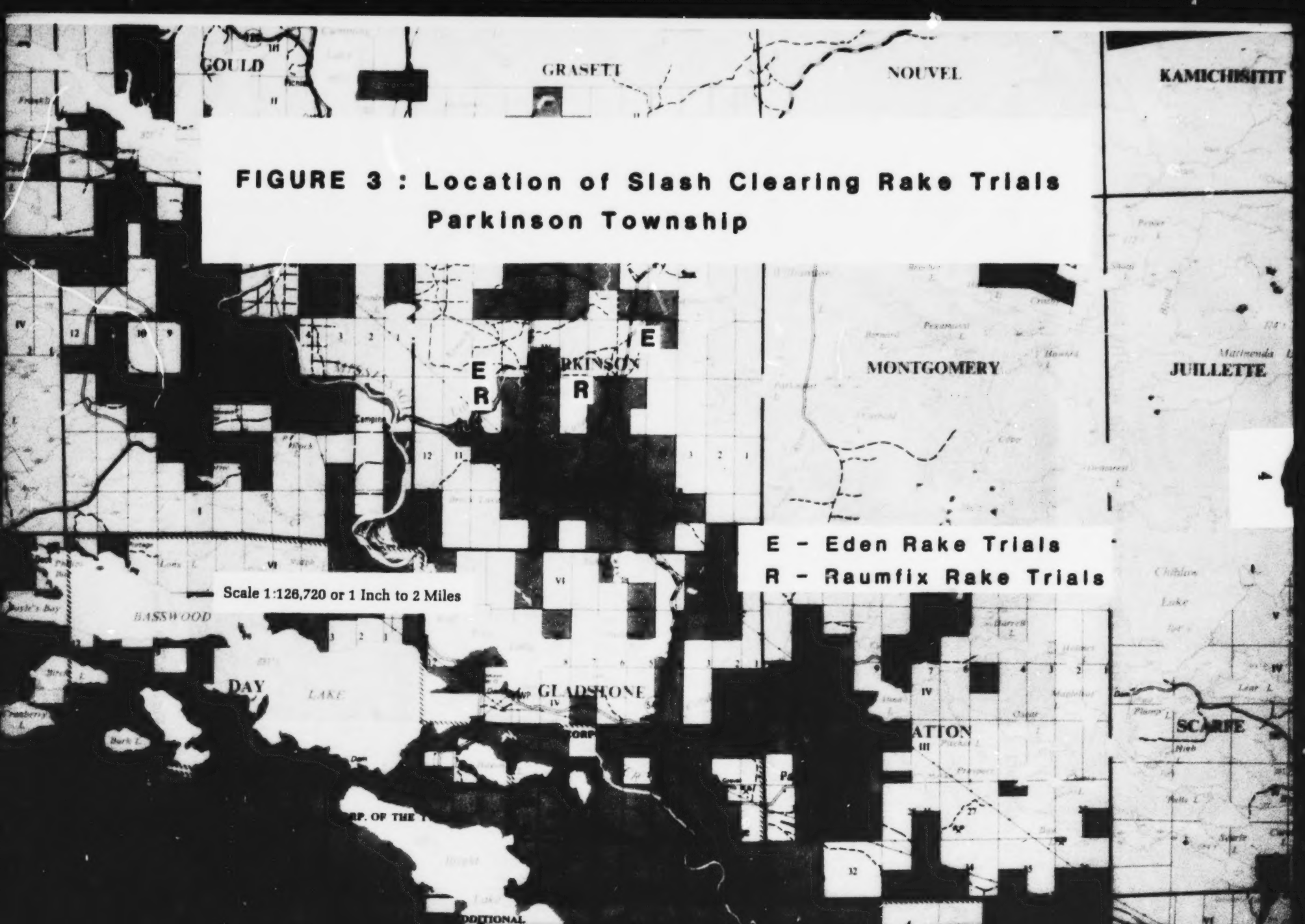

FIGURE 3 : Location of Slash Clearing Rake Trials
Parkinson Township

Table 1: Site description —
mixed conifer slash on Eden rake treated areas

Site Variable	Site 1	Site 2	Site 3
Soil depth	deep 40+ cm	deep 40+ cm	deep 40+ cm
Soil texture	fine sand	fine sand	medium sand
Soil moisture	fresh	fresh	fresh
Slope	0%	0%	0%
Area (ha)	0.9	0.5	2.9
Slash loading (kg/m^2)	1.60	1.60	1.97
Slash coverage	46%	46%	43%
Average depth (cm)	13.0	13.0	13.8
Average diameter (cm)	12.0	12.0	10.0
Average length (m)	2.5	2.5	2.1
Residuals (live): stems/ha	6	6	-
Average diameter (cm)	30	30	-
Average B.A./ha	0.41	0.41	-
Stumps/ha	250	250	250
Average diameter (cm)	32	32	32
Average height (cm)	24	24	24.6
Humus — depth (cm)	7	7	9
Poplar regeneration — stems/ha	1880	1880	1550

Table 2: Site description —
mixed conifer slash on Raumfix rake treated areas

Site Variable	Site 1	Site 2	Site 3
Soil depth	deep 40+ cm	deep 40+ cm	deep 40+ cm
Soil texture	fine sand	fine sand	fine sand
Soil moisture	fresh	fresh	fresh
Slope	0%	0%	0%
Area (ha)	4.0	2.5	4.8
Slash loading (kg/m^2)	1.13	3.16	1.16
Slash coverage	23%	56%	46%
Average depth (cm)	15.0	15.0	13.0
Average diameter (cm)	11.0	11.0	12.0
Average length (m)	5.0	4.0	2.5
Residuals (live): stems/ha	64	62	6
Average diameter (cm)	21	15	30
Average B.A./ha	2.14	1.15	0.41
Stumps/ha	282	469	250
Average diameter (cm)	29	26	32
Average height (cm)	24	17	24
Humus — depth (cm)	6	9	7
Poplar regeneration — stems/ha	7000	690	1880

Table 3: Site description
on tolerant hardwood treated areas

Site Variable	Eden rake	Raumfix rake
Soil depth	medium (15 cm - 40 cm)	medium (15 cm - 40 cm)
Soil texture	sandy loam	sandy loam
Soil moisture	fresh	fresh
Slope	0% - 20%	0% - 20%
Area (ha)	11	10
Slash loading (kg/m^2)	4.79	6.41
Slash coverage	32%	48%
Average depth (cm)	25.0	25.0
Average diameter (cm)	14.0	13.0
Average length (m)	5.0	5.5
Residuals (live): stems/ha	34	4
Average diameter (cm)	17.4	33.5
Average B.A./ha	0.83	1.6
Residuals (dead): stems/ha	7	3
Average diameter (cm)	29	54
Average B.A./ha	0.71	0.68
Stumps/ha	270	232
Average diameter (cm)	32	38
Average height (cm)	32	36
Humus — depth (cm)	6	6
Poplar regeneration — stems/ha	-	-

III

SILVICULTURAL EQUIPMENT

Eden Piling Rake

The 1090 kg Eden rake has four mechanical teeth, each controlled by its own hydraulic cylinder. The pressure in the four cylinders and the attached accumulator was set at 500 psi during the test, but can be adjusted depending on the site conditions. Before the rake was tested, the accumulator was pressurized by connecting the hydraulic system of the skidder to the rake using hydraulic lines and quick-connect couplers. After the pressure was built up to an acceptable level the charging line was disconnected.

The teeth on the Eden rake extend approximately one-half metre below the blade and are positioned at a 30° to 60° angle to the ground. The rake has been designed to ride over immovable objects such as stumps and rocks; the teeth bend backwards upon meeting an obstacle. Hydraulic pressure returns the teeth to their normal position after they have cleared the obstacle. As the teeth penetrate the ground, the mineral soil and the humus are mixed together, thus improving the quality of the site for subsequent seeding or planting.

There are several limitations to the Eden rake. Because the accumulating slash obstructs the view of the operator, it is difficult to estimate the depth of the teeth in the ground. The depth is indirectly measured by resistance; as the teeth ride deeper into the soil the resistance to forward motion increases. Overall the Eden rake bulldozes slash rather than lifting and rolling it to mix the soil and humus. The slash carrying capacity of the rake is also limited since it is not equipped with a slash accumulator, and it must be raised when backing away to prevent damage to the teeth.

Raumfix Slash Piling Rake

The 830 kg Raumfix rake has four mechanical teeth, which are at 42° to 48° angles to the ground and extend approximately 1 m below the edge of the blade. The teeth are mounted on the front of the blade by means of roller bearings and tracking guides. Each tooth is spring loaded with two springs to the back of the blade; when resistance is met the tooth is pushed up the track, extending the two springs. As resistance decreases, the springs return the tooth to its original position. From the viewpoint of

the operator, the action resembles the movement of keys on a piano. When all four teeth are extended above the blade, the operator realizes that either the rake is fully loaded or the teeth are meeting too much resistance and raises the skidder blade to dump the slash or to overcome the obstacle. The rake should be raised when backing up.

Normally, the slash is easily rolled over the ground and extends beyond the width and depth of the rake, mixing the humus and mineral soil in preparation for planting or seeding. The severity of the site preparation achieved depends on the volume and depth of the slash on the site.

IV

ORGANIZATION OF SILVICULTURAL OPERATION

The equipment trials were carried out before leaf fall in the conifer sites and after leaf fall in the tolerant hardwood sites. Both tests used the same operator and skidder in order to eliminate bias. A custom-made rake mount welded to the blade of the skidder was designed to fit both rakes.

Two patterns of travel were utilized as shown in Fig. 4. Pattern A was found to be more suitable when the tops were small and the slash loading was light. Pattern B was more suitable when the tops were large and the slash loading heavy as in the tolerant hardwood slash. Large tops had to be repositioned parallel to the rake before being pushed into the windrows.

Fig. 5 shows how the large slash was cleared.

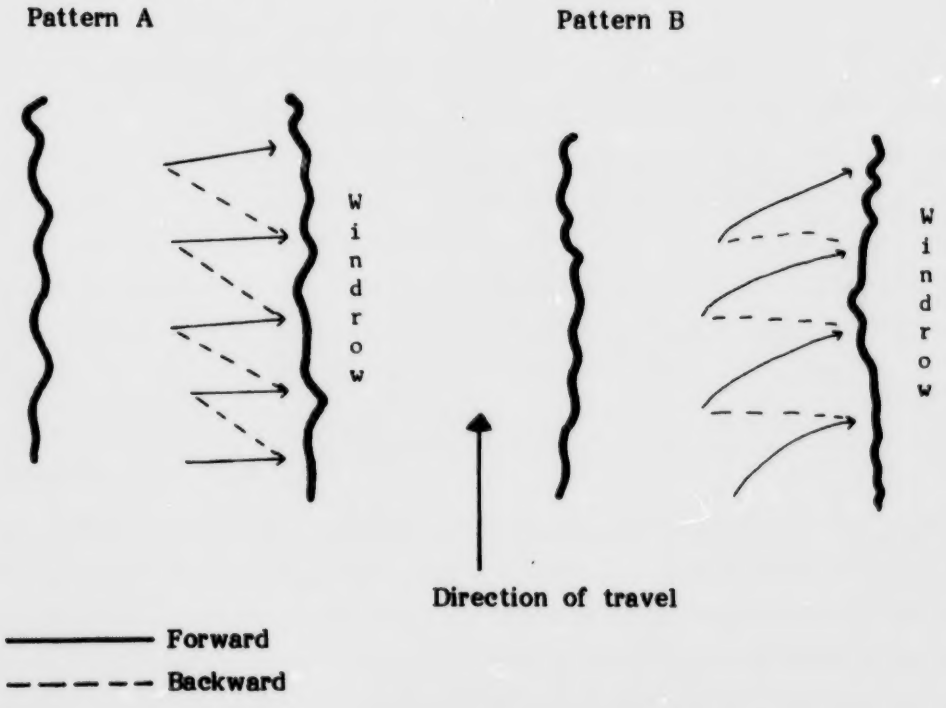

Fig. 4: Patterns of travel

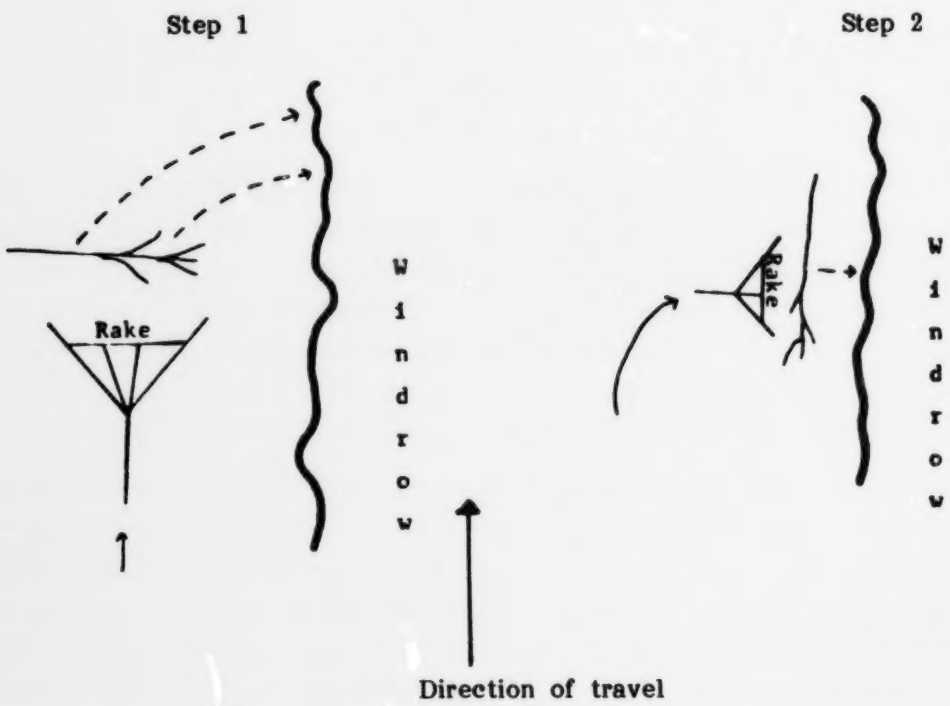

Fig. 5: Patterns of travel for clearing large slash

V

RESULTS OF EQUIPMENT TRIALS

Performance Rates

Table 4 shows the performance rates for both rakes. The machine availability of the Eden rake ranged from 55% to 96%, averaging 80% in the mixed conifer slash and 88% in the tolerant hardwood slash. Mechanical delays were caused by minor breakdowns in the hydraulic system and included seal leakages and defective shut-off valves. Repairs were simple but time-consuming; the staff was unfamiliar with the equipment and an adequate service manual was not available. The Raumfix rake achieved a machine availability of 100% on all sites.

The Eden rake was less productive than the Raumfix rake on both slash types. Machine productivities for the Eden ranged from 0.20 to 0.30 ha/PMH with an overall average of 0.26 ha/PMH in the mixed conifer slash. The lowest productivity of 0.2 ha/PMH occurred on site 2, which needed to be covered twice in order to achieve an acceptable slash reduction. In the same type of slash the Raumfix rake cleared 0.34 to 0.80 ha/PMH, averaging 0.46 ha/PMH. The highest productivity of 0.80 ha/PMH recorded on the site 3 was a result of the low number of residual trees on the site.

In the tolerant hardwood slash, 0.40 and 0.43 ha/PMH were cleared by the Eden and Raumfix rakes respectively. The Eden rake had a higher productivity in the hardwood slash than in the conifer slash where frequently it was necessary to back up to retrieve dropped slash.

Operating Costs

The data on operating costs includes all costs that would be incurred during the operation, excluding the pre- and post-site preparation assessments. Table 5 summarizes the costs per hectare when comparing the rakes for each slash type.

(a) Mixed conifer test: The high cost of the Eden rake ($443.72/ha) v.s. the Raumfix rake ($192.70/ha) can be attributed to lower machine availability and lower productivity.

(b) Tolerant hardwood test: Costs for both rakes were comparable at $237.27/ha for the Eden rake and $243.70/ha for the Raumfix rake. The Eden rake was more productive in the hardwood slash because it was not necessary to back up to retrieve dropped slash with double coverage of the area as was necessary in the conifer slash.

Table 4: Silvicultural equipment test activity sampling

	Mixed Conifer Slash								Tolerant Hardwood Slash	
	Eden Rake				Raumfix Rake				Eden	Raumfix
Type of Activity	1	2	3	Total	1	2	3	Total		
Scheduled machine hours	6.0	4.5	12.5	23.0	13.5	7.5	6.5	27.5	35.0	26.5
Non-mechanical delay hours	0.5	1.0	1.2	2.8	1.8	0.5	0.5	2.8	3.5	3.0
Available machine hours	5.5	3.5	11.2	20.2	11.8	7.0	6.0	24.8	31.5	23.5
Mechanical delay hours	2.5	1.0	0.5	4.0	0	0	0	0	3.8	0
Productive machine hours	3.0	2.5	10.8	16.2	11.8	7.0	6.0	24.8	27.8	23.5
Machine availability	55%	75%	96%	80%	100%	100%	100%	100%	88%	100%
Area (ha)	0.9	0.5	2.9	4.3	4.0	2.5	4.8	11.3	11	10
Machine productivity (ha/PMH)	0.30	0.20	0.27	0.26	0.34	0.36	0.80	0.46	0.40	0.43

Where: AMH = scheduled machine hours - non-mechanical delay hours

PMH = available machine hours - mechanical delay hours

$$MA = \frac{\text{productive machine hours}}{\text{available machine hours}} \times 100\%$$

$$MP = \frac{\text{area treated (ha)}}{\text{productive machine hours}}$$

Table 5: Costs per hectare

Type of Cost	Conifer		Tolerant Hardwood	
	Eden	Raumfix	Eden	Raumfix
Float charges	$ 13.77	$ 5.21	$ 5.28	$ 5.88
Bush lunches	4.05	1.98	2.22	2.12
AE truck charges	2.43	1.24	11.95	9.87
Prime mover cost	274.59	123.26	164.02	140.06
Field maintenance	61.72	23.56	1.67	4.00
Hydraulic fluid	5.83	-	2.22	-
Parts costs	0.49	-	-	10.11
Grease cost	-	0.25	-	0.24
Field supervisor cost	80.84	37.20	85.90	71.44
Total	$443.72	$192.70	$273.27	$243.70

Quality of Site Preparation

Table 6 summarizes the quality of site preparation achieved by both rakes.

(a) Mixed conifer sites: The initial slash loadings in the conifer trials averaged 1.85 kg/m^2 in the Eden sites and 1.59 kg/m^2 in the Raumfix sites. More slash was removed with the Eden rake at double the area coverage, leaving behind a residual volume of 0.29 kg/m^2 of slash as compared with 0.65 kg/m^2 for the Raumfix rake.

In the Eden trials the lowest final slash loading of 0.05 kg/m^2 on site 2 resulted from preparing the site twice. The high initial slash loading of 3.16 kg/m^2 on the Raumfix trials site 2 resulted in the high final slash loading of 1.38 kg/m^2.

The acceptability of the conifer sites for planting red pine (Pinus resinosa Ait.) is also shown in Table 6. Soil disturbances were measured on a series of 2 m plots. In order to contain an acceptable soil disturbance, plots must have a 30 cm by 60 cm area of (i) exposed mineral soil with up to 25% organic content, and/or (ii) exposed mixed mineral soil with up to 25% organic content, in which a hole 15 cm wide and 20 cm deep can be made for planting.

The plots with the highest acceptable disturbance rates were cleared with the Eden rake; acceptability ranged from 78% to 85%, averaging 79% on all sites.

The Raumfix rake produced plots with an overall acceptability rate of 70%, ranging from 61% to 80% depending on the site. Since a soil disturbance of 60% of the scarified area is considered satisfactory, both rakes produced an acceptable site for planting. The distribution of mineral soil exposure (MSE) within plots was slightly higher in the Raumfix trials which averaged 26% as compared to 24% in the Eden sites.

(b) Tolerant hardwood sites: The initial slash loadings on the hardwood sites were greater than twice that of the conifer sites. A loading of 4.79 kg/m^2 was encountered on the Eden site and 6.41 kg/m^2 on the Raumfix site. Although initially the Raumfix rake had a higher level of slash, the residual slash loadings were 0.72 kg/m^2 for the Eden rake and 0.71 kg/m^2 for the Raumfix rake.

After the slash clearing was completed, both sites were assessed for the amount of soil disturbance for seeding of yellow birch. In order to be considered acceptable, the 2 m plots were required to have 50% or greater (i) exposed mineral soil, copper or grey black in colour; and/or (ii) mixed mineral soil;

and/or (iii) decomposed humus.

The Eden rake produced a higher soil disturbance with 81% of the plots considered acceptable and a 20% soil disturbance within plots. The Raumfix rake had a 79% acceptability level and a 19% soil disturbance within the plots. Both rakes produced a satisfactory site for seeding since the acceptable level of 60% was exceeded for both rakes.

A greater site coverage was achieved on both sites when using the rakes rather than the bulldozers. The total site coverage ranged from 88% to 94% since only 6% to 12% of the area was lost to windrows. Site coverage using bulldozers ranges from 75% to 88%. The windrows produced by the clearing rakes were clean and could be easily burned resulting in 100% site coverage of the area.

Table 6: Post-site preparation assessment

	Mixed Conifer Slash								Tolerant Hardwood Slash	
	Eden Rake				Raumfix Rake				Eden	Raumfix
Site Variable	1	2	3	Average	1	2	3	Average		
Slash loading (kg/m^2)										
- pre	1.60	1.60	1.97	1.85	1.13	3.16	1.16	1.59	4.79	6.41
- post	0.38	0.05	0.31	0.29	0.57	1.38	0.32	0.64	0.72	0.71
Percentage of plots with acceptable soil disturbance										
- for planting red pine	81%	85%	78%	79%	80%	61%	66%	70%		
- for seeding yellow birch									81%	79%
Percentage of distribution of soil disturbance within plots	28%	27%	23%	24%	34%	24%	21%	26%	20%	19%

VI

OBSERVATIONS AND RECOMMENDATIONS

Mechanical Failures

On the Eden rake a defective tap valve and O-ring were replaced in the hydraulic system. Although there were no breakdowns on the Raumfix rake, several parts showed signs of wear and tear. These included four rubber bumpers, two extension springs, one prong, and eight lower bearings due to lack of lubrication by the operator.

In order to minimize the Eden rake down-time, spare parts should be obtained beforehand and made available at the worksite. These should include quick couplers, hydraulic hoses, tap valves, and O-rings.

Design Problems

The design of the teeth on the Raumfix rake and their method of attachment to the rake's body increased the carrying capacity by rolling the slash ahead of the blade. This feature prevented the slash from riding over the skidder blade and the engine hood of the prime mover. The design of the Eden rake, however, allowed slash to ride over the top of the blade. On one occasion, the operator had to cut a limb that had been pushed over the blade into the cab.

Difficulties were encountered with the Eden rake when it had to be winched out of the mud in hardwood sites. The teeth were designed to fold back when pressure is applied from the front of the rake; however, when pressure was applied from the back of the rake, the teeth lodged on stumps and rocks. The Raumfix teeth tended to slide over the obstructions.

Although the manufacturers recommended lifting the rakes when backing up, it was not always possible when the skidder was stuck in mud to the depth of the lower frame.

Service and Equipment Requirements

The Eden rake should be checked daily to ensure that the pressure in the hydraulic lines is adequate and the pins are tight and secure. Mounting bolts on the Raumfix rake should be checked daily and tightened if necessary. The bearings on both rakes require greasing twice per shift or every four operating hours.

The service manuals that were provided by both manufacturers were too general to be of any use, resulting in considerable delays particularly in the Eden trials. If full service manuals are not supplied by the manufacturers, on-site instruction should be provided.

The Eden rake was not equipped with a charging unit to increase the pressure of the nitrogen accumulator in the hydraulic system. Therefore, the pressure remained constant throughout the test because the local distributors of nitrogen did not have an adaptor to charge the accumulator. It is recommended that a charging unit and nitrogen tank accompany the unit in the field to enable the user to change the pressure on the teeth of the rake depending on the site conditions.

VII

SUMMARY

Both rakes mounted on 120 horsepower skidders have a higher production rate than the fixed-teeth equipped rakes mounted on crawler tractors. The Eden rake was 17% more productive and the Raumfix was 26% more productive overall.

Differences in the availability and quality of the site preparation between the two rakes are due to structural designs.

Eden Piling Rake

The following modifications are recommended to reduce recurring maintenance problems:

(a) Teeth tips: The straight teeth supplied by the manufacturer should be replaced with curved ones for better brush removal. (See Fig. 6.)

(b) The outer teeth of the rake should be made of three-inch thick material as they tend to bend inwards. (See Fig. 7.)

(c) A slash accumulator similar to the one in use with the Raumfix rake should be attached to the Eden rake to prevent the slash from rolling over the top of the rake. (See Fig. 7 for details on construction.)

(d) The lower clevis pin on a cylinder mount should be replaced with a 1 in x 3 1/2 in L.9 bolt and stover unit. This is to prevent the clevis pin from sliding out of place when a cotter pin fails to hold it in place and the cylinder's casting subsequently breaks. (See Fig. 6.)

(e) All hydraulic fittings should be shielded.

(f) Ensure that all grease fittings are accessible once the rake is mounted onto the skidder. Relocate some of them, as required, and use flexible hoses on others for accesssibility.

(g) Additional modifications may be required as more maintenance problems become apparent with increased operational experience.

Raumfix Slash Piling Rake

The following modifications are recommended to correct recurring maintenance problems:

(a) Springs: Sticks are frequently caught between the coils when a spring is extended, causing stretching and failure. A supply of spare springs is therefore a must to reduce down-time. A reliable supplier is Hamilton Wire Products Limited, 304 Gage Avenue North, Hamilton, Ontario, L8L 7X2.

The spring bolts must be supplied as shown in Fig. 8. The springs are described as extension springs with swivel ends (0.250 in x 2 in x 31.8 in) of agricultural-type wire. The cost is approximately $29 per spring (1983). An attempt was made to protect the springs by enclosing them with steel plates. However, debris clogged the enclosure and rendered the spring inoperable.

(b) Bearings: A design problem with the original bearings' mounts prevented the bearings from being properly lubricated. Fig. 9 shows how to fabricate new bearing mounts with grease holes that will ensure lubrication of the bearings. The Bristol Machine Works, 2040 Algonquin Road North, Sudbury, Ontario, telephone (705) 522-1550, made three new inserts at a cost of $130 each from a very good grade of steel (1983). Replacement bearings are manufactured by I.N.A., part #NW TR40, at a cost of $20 each (1983).

(c) Socket-head cap screws for bearing mounts: This part can be easily made from 24 mm x 80 mm cap screws by cutting them down to the required length of 65 mm; drilling along the control axis to provide for a channel for greasing; and affixing a grease nipple. A supplier is Spae-Naur, Kitchener, Ontario, part #314-099 (metric), at an approximate cost of $50 each (1983). (See Fig. 9.)

(d) Replaceable teeth tips: At least two spare sets of teeth tips should be kept on hand, depending on the amount of exposed rock material present in the area to be worked. If such tips are not readily available from the distributor, they can be made as shown in Fig. 10 at a cost of approximately $45 for each one (1983). The tips should be attached to the teeth with an L9 bolt and self-locking nut.

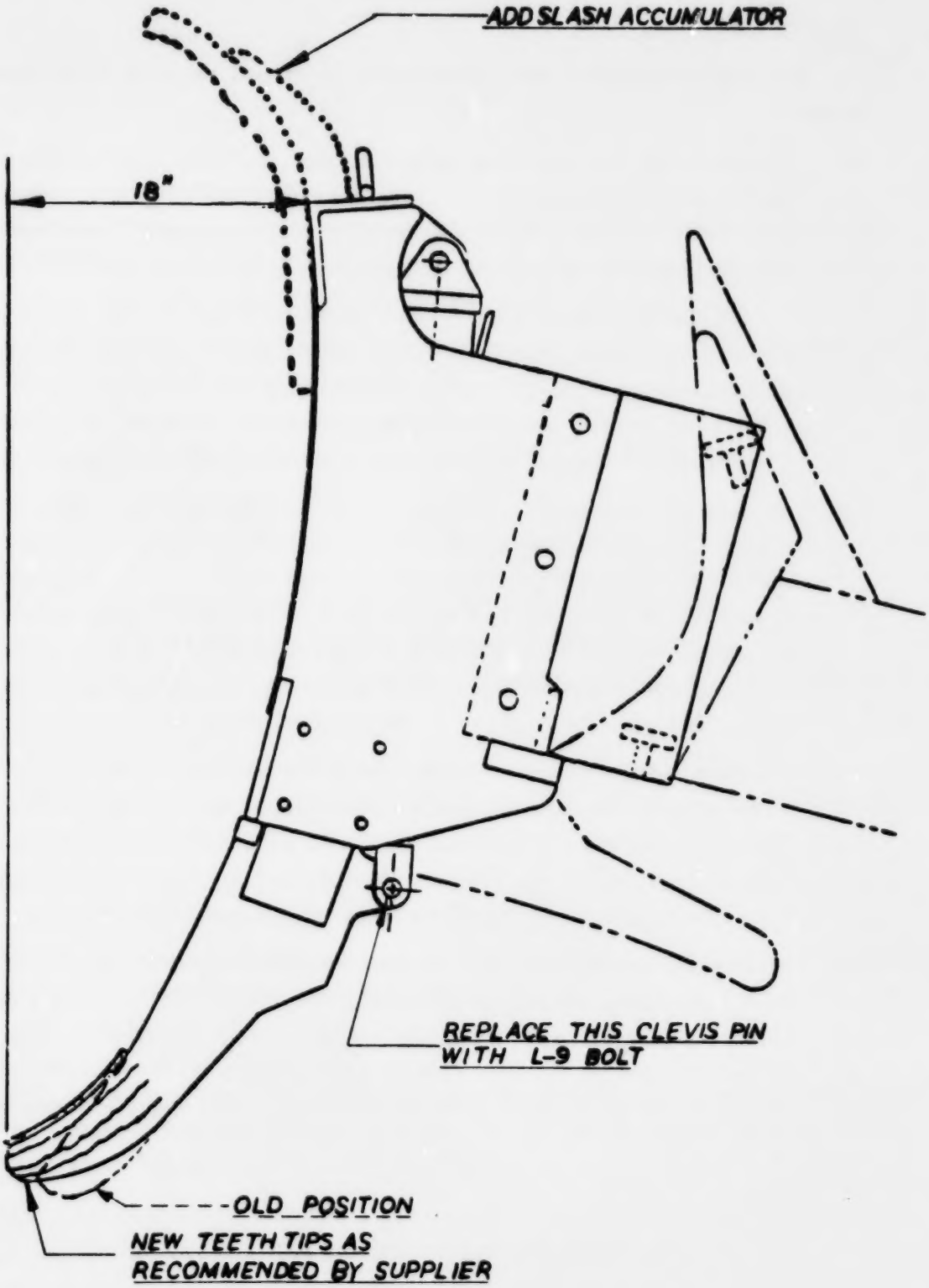

Fig. 6: Eden rake modification

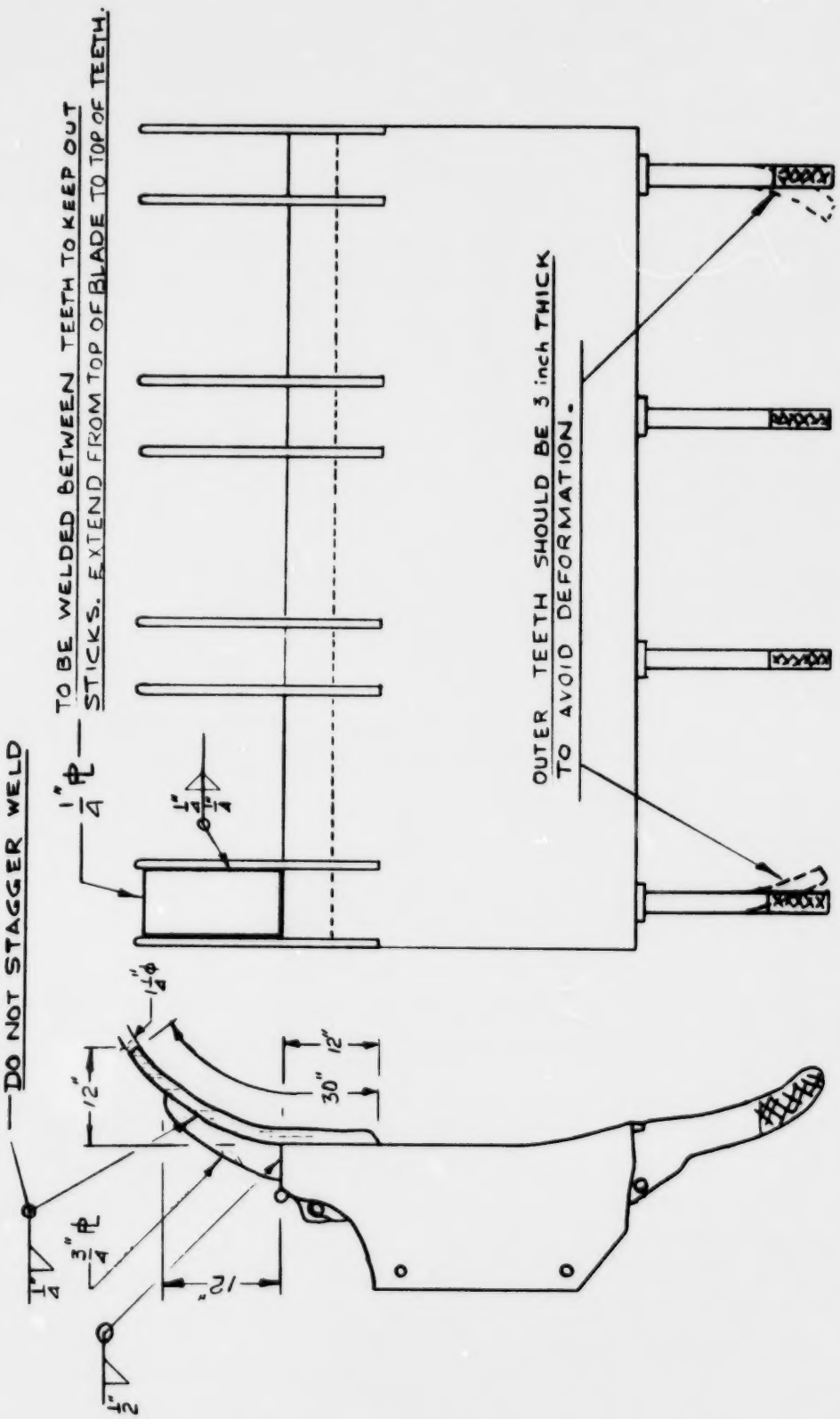

Fig. 7: Slash accumulator for Eden rake

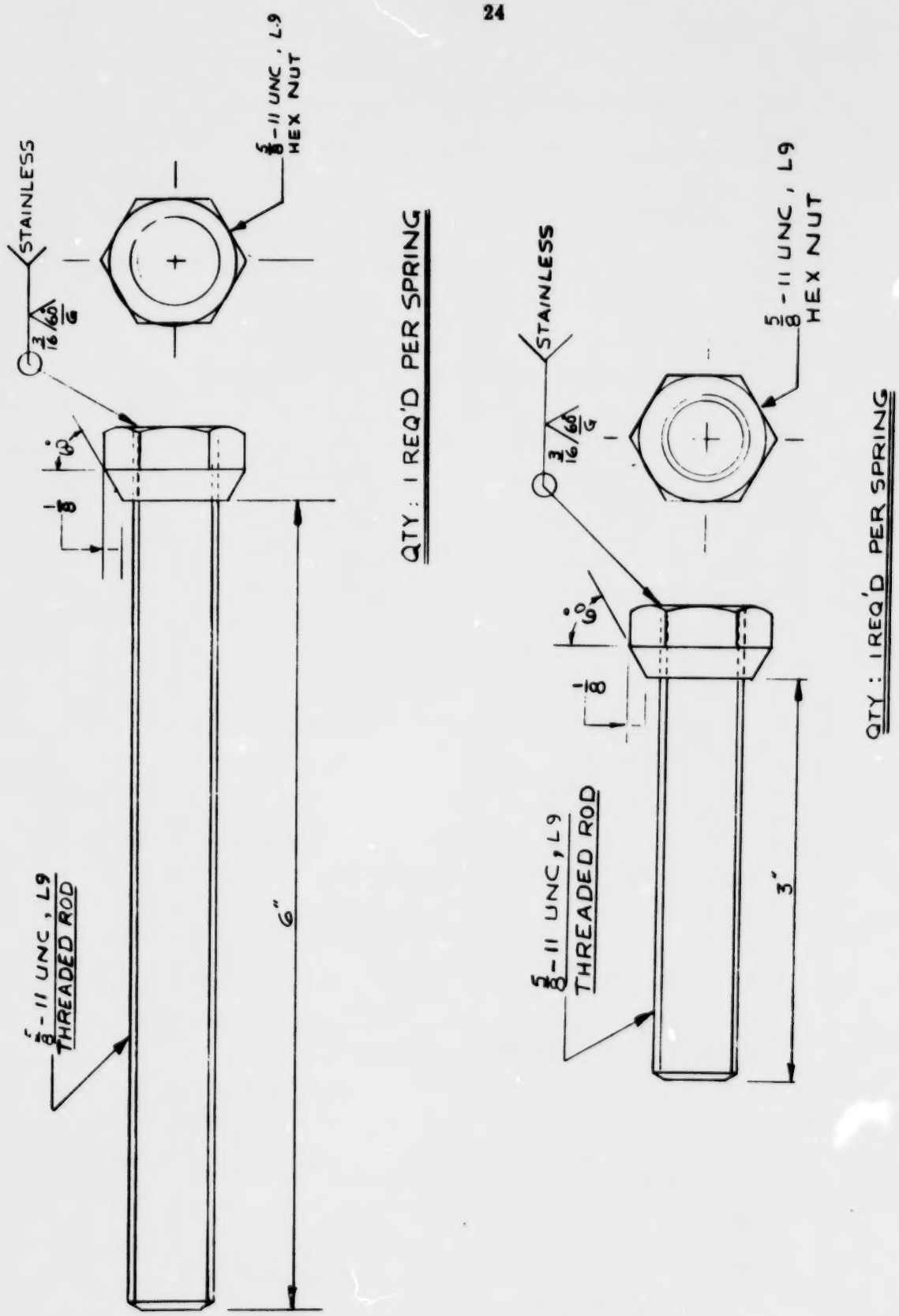

Fig. 8: Springs hardware for Raumfix rake no. 4 mod.n

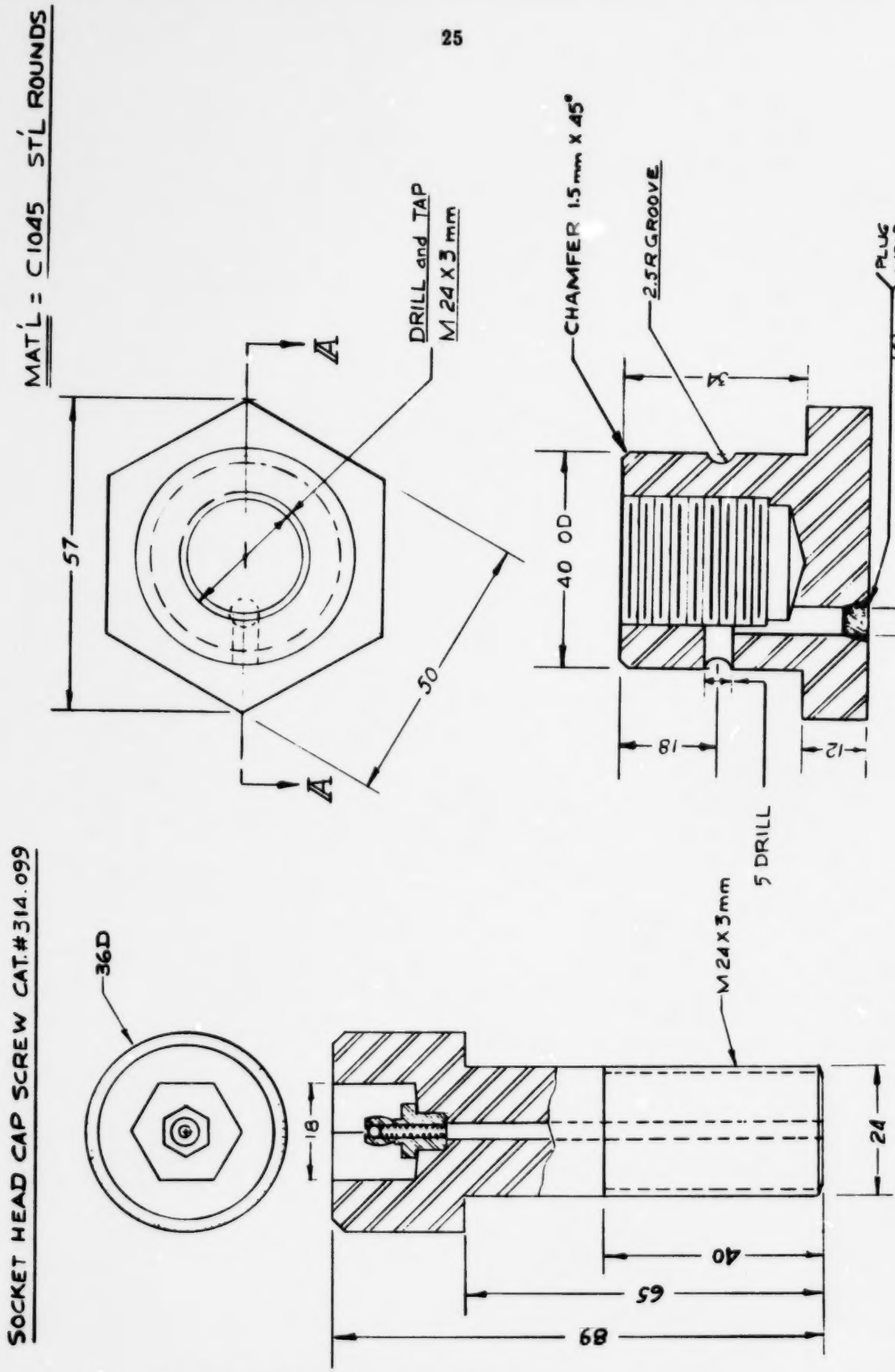

Fig. 9: Bearing mount for Raumfix rake no. 4 mod.n

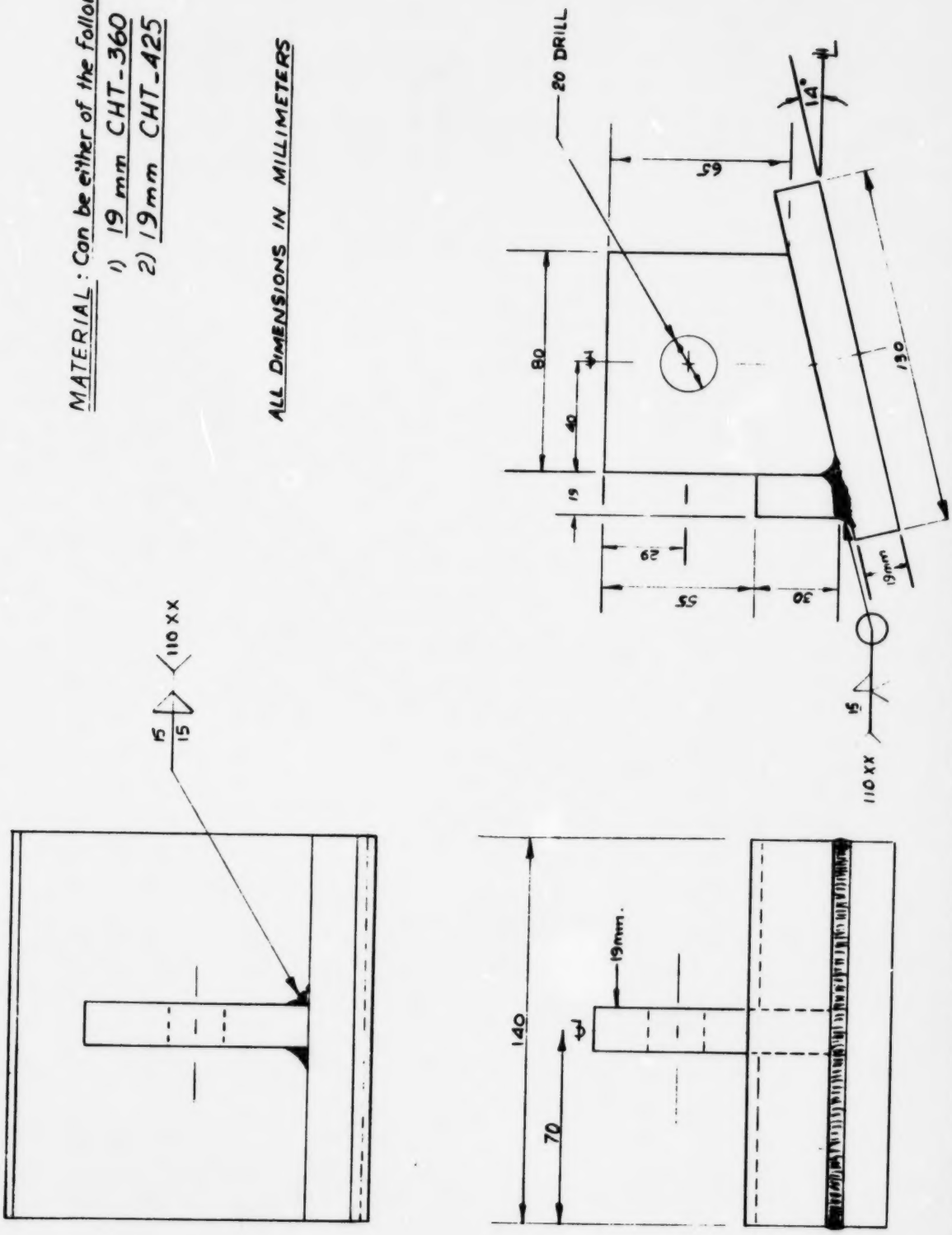

Fig. 10: Replaceable teeth tips for Raumfix rake no. 4